A DECADE OF THE SALTON SEA

By D. T. MACDOUGAL
Desert Laboratory of the Carnegie Institution, Tucson, Arizona

Extending from the lower course of the Colorado River in a north-northwesterly direction to San Gorgonio Pass, the longitudinal depression between the San Bernardino and the San Jacinto Ranges through which the Southern Pacific Railway runs to the coastal lowland of Southern California and its metropolis Los Angeles, lies a wedge-shaped basin, 185 miles long, generally known as the Cahuilla Basin. Its apex lies to the northwest; on its two long sides it is bounded by mountain ranges: on the northeast by the San Bernardino Range, the Chuckawalla Mountains, and the Chocolate Range, which separate it from the Mohave Desert; on the southwest, by the San Jacinto Range, the Santa Rosa Mountains, Superstition Mountain, and the Cocopah Mountains, the last of which separate it from the Pattie Basin, a similar depression, bounded on the west by the Peninsula Range of Lower California. In longitudinal profile the Cahuilla Basin is spoon-shaped, with the bowl to the southeast and the stem to the northwest. The rim of the bowl is formed by the delta of the Colorado River, from which the floor slopes down to 265 feet below sea level in the part nearest the stem. It is here that the Salton Sea lies.[1]

Variable quantities of flood waters have at intervals of a few years escaped from the main or effluent channels of the delta of the Colorado River and flowed down the slopes of the basin, sometimes collecting as a series of pools or lagoons at the bottom and at other times making the body of water which has been in recent times known as the Salton Sea. If the inflow continued until it overflowed the lower part of the delta which separates the basin from the Gulf of California, an area of about 2,200 square miles would be covered and the shores of the lake would be something like twenty feet above the datum taken as sea level by the U. S. Geological Survey, the bottom of the basin lying 274 feet below.

The general consensus of the physical and biological evidence is to the effect that three or four centuries have elapsed since water rose in the basin to the highest level. The number of times the lake has reached the

[1] Cf. Reconnaissance Map of the Salton Sink, California, 1:500,000, U. S. Geol. Survey, Washington, 1906.
Relief Map of the Lower Colorado River, Showing Irrigable Lands in the United States and Mexico, January, 1905 [photograph, 1:1,250,000, of a relief model]. Accompanies "The Salton Sea" by F. H. Newell, *Ann. Rept. Smithsonian Inst. for Year Ending June 30, 1907*, pp. 331-345.
Map of the Desert of the Colorado, compiled by G. Sykes [1:800,000], Pl. 2, "The Salton Sea: A Study of the Geography, the Geology, the Floristics, and the Ecology of a Desert Basin," by D. T. MacDougal and collaborators, *Carnegie Inst. Publ. No. 193*, Washington, 1914.
Map of the Delta of the Colorado River, Including the Salton and Pattie Basins, compiled and drawn by Godfrey Sykes [1:1,500,000]. Accompanies "The Desert Basins of the Colorado Delta" by D. T. MacDougal, *Bull. Amer. Geogr. Soc.*, Vol. 39, 1907, pp. 705-729.

maximum is not clear; some writers are disposed to favor the inference that it stood so high but once in its history and then perhaps for less than a century. Loss by evaporation in this region is such that of a possible total of 116 inches, a layer of 40 to 60 inches passes off in vapor every year. If the lake were filled to its high level by a single flood, and thereafter received nothing but the drainage of the surrounding slopes, nearly a

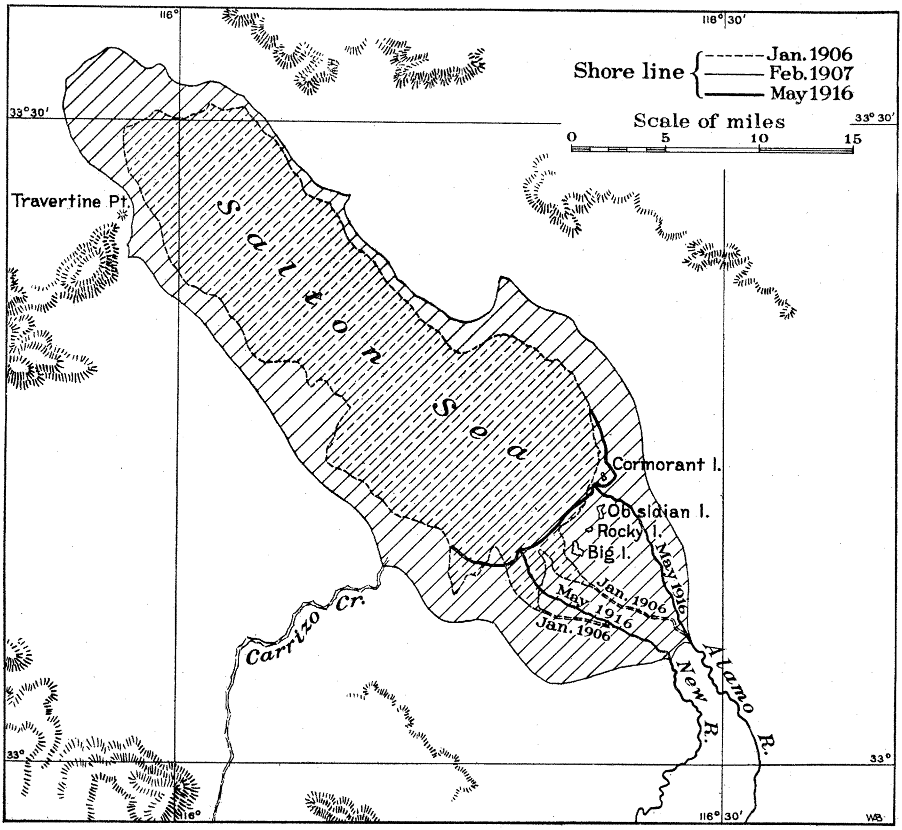

FIG. 1—Sketch-map of the Salton Sea showing levels of January, 1906, and February, 1907, and position of delta and lower course of the New and Alamo Rivers in May, 1916. Scale 1:650,000. (January, 1906, shore line based on "Reconnaissance Map of the Salton Sink, California," 1:500,000, U. S. Geological Survey, Washington, 1906.)

century would elapse before it dried up to leave the white saline beds on its bottom.

The earliest notice of floods escaping into the basin is of 1840, followed by others of 1842, 1852, 1859, 1862, and 1867, and but little is known of the body of water accumulating in the basin in each case. A notable inundation occurred in 1891, when the water came near the line of the Southern Pacific Railway and a representative of a newspaper followed a stream of water from the main channel of the Colorado River down into

the lake itself. These occurrences within recent time are probably continuous with the earlier history of the basin.

When a lake has once been made, its recession is a halting one, with many partial returns toward the maximum level and perhaps a few actual refillings. However this may have occurred, the heavy deposit, formed on the rocks which were a few feet below the surface at the high level, yields irrefutable evidence that either in one period or in several periods the lake stood full or nearly so for a time sufficient for the organic formation of a travertine layer one to three feet in thickness. The halting and irregular recession of the lake is finely recorded in the terraces which are formed when the water stands a few months at any given level. The upper two hundred feet of a gravelly slope near the railroad station of Salton shows 83 of these shelves or benches of assorted material, as has been determined by Professor Ellsworth Huntington and the writer. The terraces remain as one apparent series, however, and no means has yet been found for distinguishing between those of an older lake on the higher slopes and more recent benches near the bottom resulting from the action of a smaller lake.

The conclusions as to the oscillation and refilling of the lake were therefore based simply on allowable assumptions until early in 1915, when a discovery was made which placed the matter on a basis of record of some historical value. In the tufa coating on an outlying mass of fragmented granite projecting into the southwestern side of the Cahuilla Basin a number of carved designs of Indian origin were found by us in 1906, and had probably been seen by earlier visitors to the place. The formation is designated as "Travertine Rock" and "Travertine Point" in our various publications. The crest rises a few feet above the maximum level of the lake and would have showed as a small rocky islet. A few feet below high-water mark the deposit of tufa reaches a thickness of several feet. Below this the tufa or travertine is not so heavy, thinning down to a few inches near the base of the granite mass. Now this tufa is a lime formation which is made only in fresh or slightly brackish water, and as it seemed highly probable that the occurrence of the carvings might yield some evidence on the history of the lake, a special visit was made to this place in company with Mr. Godfrey Sykes in March, 1915, for the purpose of making a more careful examination of the formation. The half-light of a cloudy day was favorable to the discovery of a large number of carved figures. Some of these showed as deep furrowings visible at a hundred yards, and others were so faint as to be barely discernible (see Fig. 5). Cuttings made through some of the lines showed that none of the carvings had been made in the granite but were chipped in the travertine deposited on it. Next it became clear, upon examination of polished slices of the rock, that some of the cuttings had been subsequently coated with additional layers of travertine. This would indicate that after aboriginal man came into the region and acquired the art and habit of making such figures, he frequented

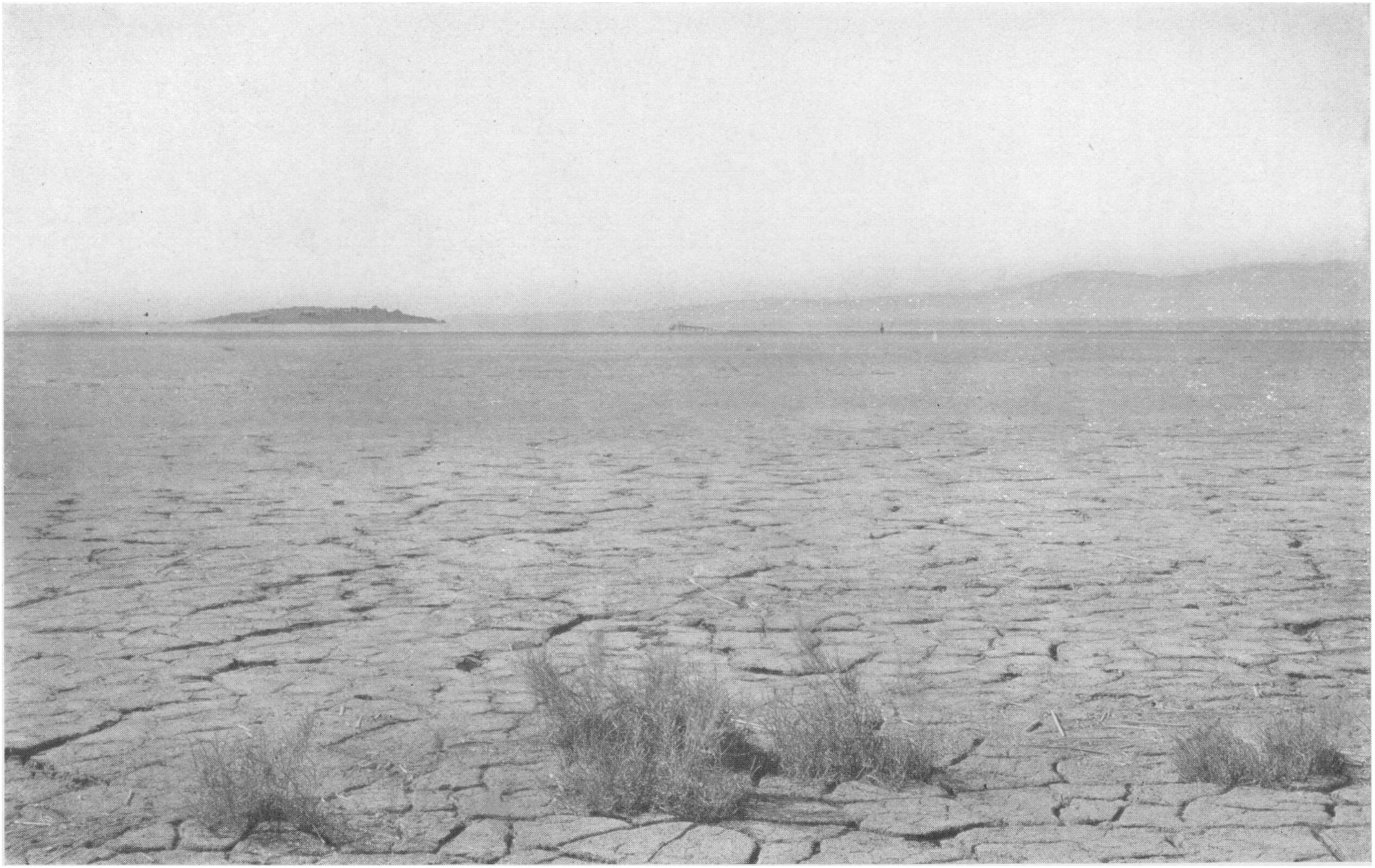

FIG. 2—Salton Sea: view across strand of 1915 and across strip of water to Cormorant Island. The plants of pickleweed in the foreground mark the lower limits of the strand of 1914. Photographed May, 1916.

FIG. 3—Terraces formed by the lake in the winter of 1915-16. Strand of 1915, devoid of vegetation, on the left; water receding from the terrace on the right. May, 1916.

this bold foreland and cut his symbols of lightning, of storms, and of the serpent; then the lake rose and coated them over. With its recession a few years or a century later, the place making its natural appeal to the primitive mind as suitable for records, other carvings were added from time to time. Much importance must have been attached to recognizable figures uncovered by the lake. It is notable, however, that none of the figures were made in the present surface of the travertine, a condition paralleled by series of carvings in many places in Arizona. Whatever may have been the reasons for the discontinuance of the making of figures on any ordinary "pictured rocks" it is clear that a full lake came after all made on Travertine Point. After these undated records of the aborigines came the explorer, and the hope still survives that the records of the Spanish expeditions of the sixteenth and seventeenth centuries may yet yield some notes as to this region, in addition to Rocque's map of the eighteenth century.[2]

The influx of a body of fresh water into a saline basin which in ordinary times was a desert of a very pronounced type might be expected to be accompanied by serious disturbances of the physical conditions, which would be reflected in the behavior and geographical relations of the plants and animals of the region. This may be best understood when the topographical and meteorological conditions are recalled. The basin is subject to a mixed type of climate. It lies far enough inland for overheating to result in a continental type of climate, particularly with respect to the rainfall. Its great bowl, however, lies immediately in the lee of a great mountain range which rises abruptly from its southwestern side, with the result that fringes of mountain storms reach out over part of its area at times, while the topographical conditions favor the development of the intense and localized precipitation known as cloudbursts.

The annual average rainfall from data covering thirty-six years is 2.74 inches, and the character of the precipitation phenomena suggests a high degree of aridity. The maximum amount of rain received in one year was 7.10 inches (1906) and the lowest, a "trace" (less than .01 inches), in 1904, giving a variation as 1 to 1,000, a proportion occurring in deserts of a pronounced degree of aridity only. Another method of characterizing deserts according to their aridity is to give the ratio of possible evaporation from a free-water surface to the annual amount of precipitation. In the Cahuilla Basin about 116 inches of water would evaporate during a year from the surface of a small vessel on the ground in the open; this is fifteen times the amount which has fallen in any one year; forty-three times the average, and many thousands of times the minimum. The region is in fact a desert of the most advanced type, in which desiccation has progressed to such an extent as to reduce the native flora to less than 140 species of seed plants.

The setting and the constructive arrangement for an experiment which

[2] See Pl. 2, *Carnegie Inst. Publ. No. 193* (title cited in footnote 1).

would test the effects of a body of fresh water on the native organisms of such a desert were made when a company, organized for the purpose of irrigating an area in the basin, began "the task of connecting and clearing the various channels which formed the natural waterway between the river and the basin; and by the middle of 1901 water was flowing upon the irrigable lands of what has since become known as the Imperial Valley. It had been deemed advisable by the promoters of the scheme to take the water from the river in United States territory, and so the upper section of the canal was cut almost parallel to the river for several miles and with a very low gradient. This circumstance, together with the general unsuitability of the site selected for the head works, caused considerable trouble for two or three years, as more and more water was required to fulfill the demands of the growing communities in the desert; and so various openings were made between the river and the canal in order to furnish a more adequate supply.

"Then, in the winter of 1904-05, one of the infrequent winter floods in the Colorado, coincident with a tremendous rush of storm waters from the Gila, found before itself the unprotected head and comparatively steep downward grade of the canal, and at once began to cut and enlarge the channel. The ordinary summer flood of 1905 also poured its water through the opening, and it was soon realized that the outpour had got beyond control.

"Practically the whole of the Colorado was now flowing into the Salton Basin, and another flood in the following November (1905) made the task of closing the breach seem almost hopeless, although the most strenuous efforts were being made by the engineers; and it was not until February, 1907, that the Colorado was finally returned into its former channel."[3]

The lake formed had a depth of from 80 to 85 feet, and the total area of this latest Salton Sea was estimated at from 450 to 500 square miles (see map, Fig. 1).

Field plans of the Desert Laboratory staff for the study of the surface phenomena of arid regions were put into final form in 1906, and the Salton Sea offered an unexampled opportunity for the measurement of its recession and the observation of the accompanying successions of vegetation from aquatic to desert conditions.

The actual number of species of plants native to the Cahuilla Basin comprises less than 140 ferns and seed plants, of which five, or three per cent of the whole list, are endemic and the greater number are suitable for existence in saline soils. The influx of the flood waters brought the seeds of a large number of species of land and shore plants from along several hundred miles of the Colorado River, and these, together with the seeds which had been floated from the dry slopes of the basin, were cast on

[3] D. T. MacDougal: The Salton Sea, *Amer. Journ. of Science*, 4th Series, Vol. 39, 1915, pp. 231-250; quotation on p. 235.

FIG. 4.

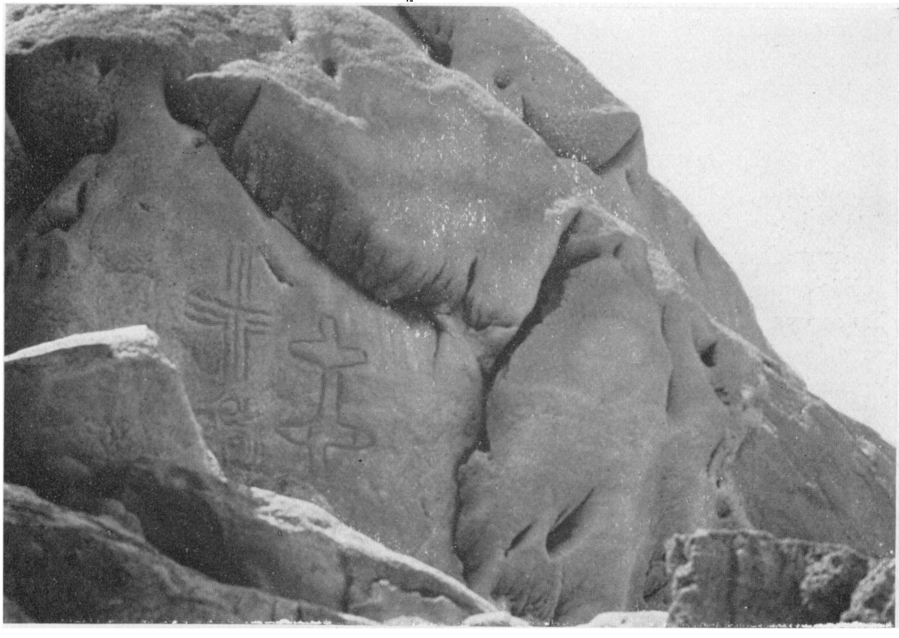

FIG. 5.

FIG. 4—Salton Sea: dense vegetation on beaches of Obsidian Island, strands of 1907 to 1912.
FIG. 5—Figures in the travertine on Travertine Point.

Fig. 6.

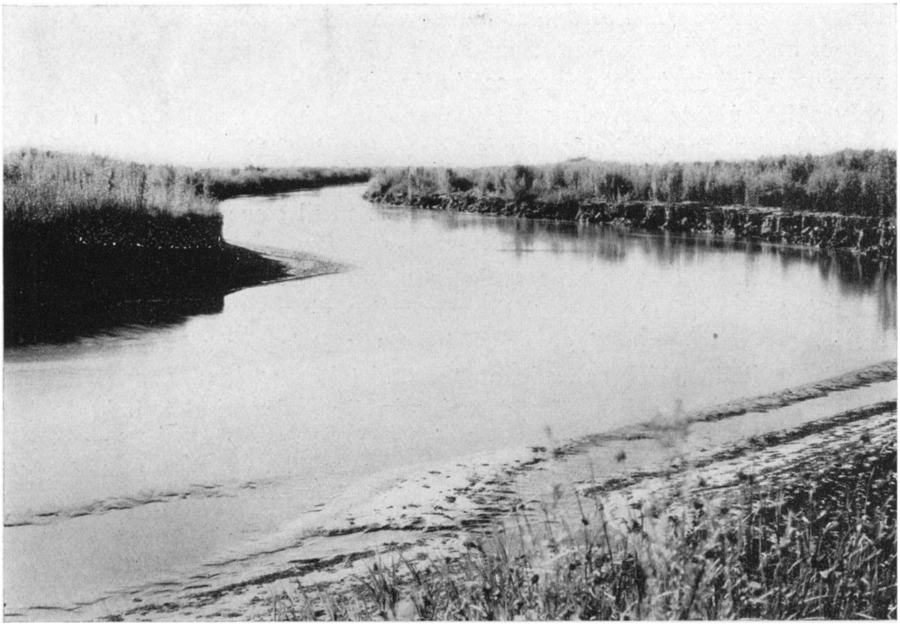

Fig. 7.

Fig. 6—Delta of the New River. Effluent leading off to the right one-fourth of a mile to the margin of the lake. May, 1916.

Fig. 7—Channel of the Alamo River above recent high level of the lake, carrying average flow into the lake. May, 1916.

the moist shores of the lake. The water remained practically stationary at its highest level but a few hours, and then the loss by seepage and by evaporation was so great that the margin receded several feet per day on the gentler slopes, so that in some places around the southeastern end of the lake a strip a mile or more in width was laid bare in a year. This emersed strip of 1907, having been washed by the water in its freshest stage, was sown with the seeds, including the greatest number of species possible under the circumstances, with the result that in the cooler season at the end of this year dense ranks and belts of vegetation occupied the shores much as if the lake were of fresh or brackish water, and these zonal formations included the greatest number of species yet seen about it. In the succeeding years the water was a more concentrated solution of the contained salts, the supply of seeds from the river was cut off, and consequently the beaches, now increasingly salty, were less richly sown each year, with the result that by the spring of 1916 only a few species appeared on the shores recently abandoned by the lake. This fact was taken to mark the end of the first stage of the recession of the lake and concluded a period in which the muddy shores were at first occupied by ordinary land species, some of which failed to appear in the succeeding years, until at the present time only pickleweed *(Spirostachys occidentalis)*, seablite *(Suaeda torreyana)*, sea-purslane *(Sesuvium sessile)*, salt bush *(Atriplex canescens)*, and beach-heliotrope *(Heliotropium curassavicum)*—species common to saline shores and salty areas—come on the beaches. The newly emersed strips were occupied during the first year in the earlier stages of the lake, but now only a few plants come in until the soil has been bare for a year. It is probable that one of the factors in the matter is that of the oxygen in the soil. The ground now being laid bare is closely packed and saturated, and the pioneer species cannot grow in it until some aëration has taken place (Fig. 4).

The definite close of the cycle in pioneer occupation has also called attention to another phase of the vegetative phenomena, that of the successions or changes on the emersed beaches. It is easily to be understood that the plants which came in on the moist belt of land from which the lake receded in 1907 could not maintain themselves indefinitely in that place. The original supply of moisture not being replenished in any adequate manner, the fresh-water pioneers slowly succumbed to increasing desiccation, which in turn offered favorable conditions for desert species. The succession or changes from the condition of close-ranked moisture-requiring species to that of the open formations took place so rapidly that the nearly static condition of the latter might be reached in a half-dozen years or even less. In fact many square miles of territory submerged in 1906 and 1907 have now returned to the desert conditions previously prevalent (Fig. 3).

The conditions of salinity in the water of the lake have likewise made

a similar succession, but for the most part of organisms not visible to the eye. The water at the maximum level of the lake contained about one-third of one per cent of dissolved matter, and its use as drinking water was a matter of friendly competition among the members of the exploring party who circumnavigated the lake at this time and the results were given in our publication on this subject as follows[4]: "The water at this time [February, 1907] contained about 0.25 per cent of dissolved salts, which is near the limit of potability. This was denoted by the fact that it could be used by some members of the party, but not by others."

Potability is in itself a very uncertain feature of waters in desert regions, as has been most adequately set forth by Phillips as follows[5]:

> "Drinking water" is a *façon de parler* in the desert. Threepennyweight of salt to the quart [about .5 per cent] is enough, as the reader will find if he tries, to give it a strong briny flavor. Such water, however, is freely drunk in the Sahara. Horses, camels, and donkeys even thrive on water containing nearly half an ounce of salt to the quart. It varies very much in different neighborhoods, but is always distinctly brackish and generally impregnated besides with potash, magnesia, sulphuric acid, and other delicacies, to such an extent that the old custom of poisoning the wells always struck me as a very superfluous one.
>
> All things, however, adapt themselves to it. Water that will appease the thirst of an Arab would only aggravate that of a European.

The facts and the cited comment are given place, since a reviewer has made the statement that no reference was made to the potability of the water in the Salton volume.[6]

The results of the annual analyses incorporated in the table on page 468 were carefully scrutinized every year for the purpose of detecting changes in the composition of the water which might be correlated with the behavior of the plants affected by the water. During the first year of the recession of the lake the chief mineral constituents increased so that the amount present was about 19 to nearly 21 per cent greater in 1908 than in 1907. This increase was shared by the calcium. In the following year, while the sodium increased 19.4 per cent and the potassium 16.5 per cent, calcium increased but 7 per cent and in the following year but slightly more. Coincidently the missing calcium was found as a lime deposit on the branches of submerged shrubs, stones, and other objects. The amount of calcium in the solution had by no means reached the saturation point, and other causes must be brought in to account for the deposition. The above applies also to some extent to the course of concentration of the magnesium. The only available inference is that the lime and magnesia were being brought down by the action of a plexus of algae and bacteria. The inferred presence of these organisms would carry with it the implication that the formation of the lake would be followed by their multiplica-

---

[4] *Carnegie Inst. Publ. No. 193*, p. 117.

[5] L. March Phillips: In the Desert and the Hinterland of Algiers, London, 1909, pp. 184 and 185.

[6] See Mark Jefferson, *Bull. Amer. Geogr. Soc.*, Vol. 47, 1915, p. 885, who says in a review of "The Salton Sea": "We do not learn whether the Salton Sea was, or is now, drinkable."

TEN COMPLETE ANALYSES OF THE SALTON SEA WATER

	Parts per 100,000									
	June 3, 1907	May 25, 1908	June 8, 1909	May 22, 1910	June 3, 1911	June 10, 1912	June 18, 1913	June 12, 1914	June 8, 1915	June 10, 1916
Total solids (dried at 110° C.) plus water of occlusion and hydration	364.8	437.20	519.40	603.80	718.00	846.55	1002.56	1179.6	1377.4	1647.2
Water of occlusion and hydration	....	....	17.50	22.56	20.84	23.9	32.6	36.2	42.2	47.5
Sodium, Na	111.05	134.26	160.33	189.28	227.81	270.71	323.08	381.47	441.6	528.9
Potassium, K	2.30	2.78	3.24	3.53	3.81	3.81	3.45	4.01	5.2	5.71
Lithium, Li	trace	0.013	0.017	0.021	0.025	....	....	....	....	....
Calcium, Ca	9.95	11.87	12.70	13.67	15.62	17.28	19.75	22.22	25.27	29.85
Magnesium, Mg	6.43	7.63	8.96	9.84	11.68	13.62	16.22	19.03	22.63	27.17
Aluminum, Al	0.030	0.035	0.062	0.040	0.089	0.100	0.125	0.140	0.032	0.034
Iron, Fe	0.005	0.006	0.010	0.008	0.036	0.042	0.038	0.012	0.020	0.060
Silicate radicle, SiO_4	1.41	1.43	1.59	1.55	1.83	1.79	2.18	2.42	1.55	1.21
Manganese, Mn	....	....	....	....	....	....	....	....	....	....
Lead, Pb	....	....	....	....	....	....	....	....	....	....
Copper, Cu	....	....	trace	trace	trace	....	....	trace	....	....
Chlorine, Cl	169.75	204 05	240.90	280.93	339.42	395.44	473.89	559.66	650.95	787.64
Bromine, Br	....	....	....	....	...	....	....	....	....	....
Iodine, I	....	....	....	....	....	....	....	....	....	....
Sulphate radicle, SO_4	47.60	56.74	65.87	76.36	91.67	106.83	124.65	148.10	174.47	207.89
Carbonate radicle, CO_3	6.58	7.66	7.34	6.38	5.78	12.09	11.28	10.96	11.92	11.40
Arsenate radicle, AsO_4	....	....	....	....	....	....	....	....	....	....
Phosphate radicle, PO_4	0.009	0.011	0.01	0.013	trace	trace	trace	....	....	doubtful
Nitrate radicle, NO_3	0.18	0.20	....	....	....	trace	....	....	....	....
Nitrite radicle, NO_2	....	....	0.0006	....	....	....	....	....	....	trace
Oxygen consumed	0.093	0.059	0.068	0.045	0.063	0.072	0.110	0.110	0.208	0.170
Borate radicle, BO_2	....	trace	trace	trace	trace	....	trace	trace	trace	trace

tion and development, which was such that the maximum formation of tufa or lime deposit was greatest in 1909 and 1910, during which period the amount thrown down was sufficient to account for about half of the expected increase in concentration of lime. In succeeding years this action was not so marked.

It is notable that the travertine deposit on the slopes of the basin is of a parallel nature. The heaviest deposit is a few feet below the maximum level of the lake and then thins down toward the bottom. The decrease in deposition does not coincide with a poverty of material and may therefore be reasonably ascribed to a modification of the activities of the organisms. Thus, while some calcium and magnesium is being lost from the solution, it now no longer comes down as coatings on objects in place, and it probably settles in the form of minute particles, although the almost ceaseless motion of the water prevents it from forming a definite and visible layer.

A somewhat similar fluctuation of the potassium in the water is as yet unaccounted for. Thus no increase of this element occurred in the year ending June, 1912, and an actual decrease followed.

Any discussion of the influence of the lake on the surrounding region would be incomplete without the mention of the fantastic popular notion that the climate hundreds of miles away was modified by its tempering action. The presence of the lake, of course, implies a blanket of vapor pressed shoreward by the prevailing winds, and it was obvious that the heightened humidity did exercise an effect on vegetation within a few hundred yards of the shore.

The most marked effect on the vegetation of areas not actually affected by the submergence was that resulting from the checked underflow from the mountain slopes on the southwestern shore of the lake. The water thus prevented from escaping to lower levels accumulated and was forced so near to the surface as to be available for plants, which showed a luxuriance much beyond that prevalent in the empty basin.

Somewhat sensational is the emergence, after the recession of the lake, of the mud volcanoes which lie on the northeastern slopes of the basin near some hills which have become islands. These vents were covered with water in 1907, and, although the course of sail boats and launches was laid over them, nothing was seen of them until late in 1915, when they began to boil up irregularly through the water when it came down to a depth of five or six feet, sometimes throwing a mass of mud several feet above the surface. Vents entirely uncovered resumed activity in boiling pools, with a notable emission of gases (Fig. 8).

Four volcanic hills lie on a north-south axis in the southeastern part of the basin. The summits of three of these remained above the level of the water in 1907, and the occupation of the beaches around these islands by vegetation has been described in detail elsewhere[7] (see also Fig. 4).

[7] *Carnegie Inst. Publ. No. 193*, p. 125 ff. and 168 ff.

FIG. 8—Salton Sea: mud volcanoes in the strand laid bare in 1915 through the recession of the lake. May, 1916.

Wind-borne seeds and floating seeds, root-stocks, and seedlings found lodgment on the moist strands, resulting in a series of successions not essentially different from that on the main shores of the lake. These three higher hills have now become joined to the mainland.

The smallest hill of the group, however, was so nearly covered by the floods that its summit was repeatedly washed by the slightly salty water in 1907, and it was therefore considered as sterilized of all of the seed plants. Its emersed portion, which was designated as Cormorant Island, offered an unusually interesting area upon which the occurrence of plants could be followed with some exactness. Two miles of water separated it from the nearest island, and in 1908, at which time the first two individual plants were found, six or seven miles of water separated it from the main shore. These two pioneers were "arrow-weed," *Pluchea sericea,* and *Baccharis glutinosa.* The census of the plant population of the island was taken again in 1912 and in May, 1916, the analysis of the population being as below:

REVEGETATION OF CORMORANT ISLAND

Eleven Species	Number of individuals 1908	1912	1916
Atriplex lentiformis	..	5	35
Baccharis glutinosa	1	2	..
Cryptanthe barbigera	..	..	1
Distichlis spicata	..	..	1
Erigeron canadensis	..	..	2
Heliotropium curassavicum	..	2	15
Lactuca asper	..	..	2
Pluchea sericea	1	2	4
Rumex berlandieri	..	..	1
Sesuvium sessile	..	2	5
Spirostachys occidentalis	..	20	404
Total— 2 species	2	..	..
Total— 6 species	..	33	..
Total—10 species	..	..	470

The total number of species now occupying the island is probably as great as when it was a desert hill. It is to be noted that 460 of the 470 individuals on the island are salt plants, and that one of the pioneers, *Baccharis,* has already been lost.

The general features of dissemination by which these species may have reached this island across the intervening expanse of water has already been discussed in full[8] and will not be described in detail here. *Baccharis, Erigeron, Lactuca,* and *Pluchea* have plumed seeds which are readily transported over intervals of a few miles by gales or gusts of wind. The seeds of *Atriplex* float, and, as germination may ensue in the water and as the plantlets may float about for some time and then take root upon stranding,

[8] *Carnegie Inst. Publ. No. 193,* p. 125 ff. and 168 ff.

it is evident that a strip of water a mile or two in width instead of being a barrier might even facilitate the travels of this plant. The seedlings of *Sesuvium* and *Spirostachys* may also float about for some time and take root when cast ashore, and *Rumex* might be carried about in the lake in the same manner. Very small seeds such as those of the *Heliotropium, Spirostachys,* and *Sesuvium* may be picked up and carried long distances by the winds.

The reoccupation of this island has been studied with perhaps greater care than that of any other area which has ever come under the observation of a naturalist. The dissemination of plants by the flotation of seedlings seems to be a hitherto undescribed mode of travel by plants. Although the most serious efforts were made to detect the transportation of seeds by birds after the manner upon which so much has been written by Darwin and others, no well-proved case was found. The inference was strongly to the effect that the burrlike fruits of *Cryptanthe* had been carried to Cormorant Island and also to other beaches by birds.

The great trough in which the Salton Sea lies has been partially filled by alluvium carried into it by the Colorado River, which has finally built a great dam separating the trough from the Gulf of California. Every inflow has carried its contribution of sand and silt, the greater portion of which would naturally be deposited in the southernmost part of the trough, with the result that the surface has been raised to form a dam separating a part of the trough from the Gulf of California as the present basin. The present filling of the lake was exceptionally effective in this way. The silt-laden waters of the Colorado which flowed into the basin in 1904-07 through the streamways designated as New River and Alamo River cut deep and wide channels in the alluvium and carried down below the recent water levels a mass of material amounting to about twice the total taken out in excavating the Panama Canal, or one-fourteenth of a cubic mile (Figs. 6 and 7). The silt-laden water of the Colorado River deposits about 6 per cent of its volume as dried soil, so that the total fill left by the present flood is estimated as amounting to about one-third of a cubic mile. Otherwise stated, the present Salton Sea will leave below its high level one-twelfth of its volume in soil. This material is of course unevenly distributed, and every inundation of the basin results in filling and altered surfaces. The change in contour is especially noticeable at the present time and is readily observable since the lake in 1916 stood nearly at the same level as in January, 1906. The low inclines into which arms of the lake extended a decade ago are now filled, and the channels of the two inflowing streams now follow into the receding lake on lines widely variant from those used in the formation of the lake (Fig. 1). It is obvious that all of the alluvial fill in the basin might be accounted for by the floods of the last few hundred years and that all of the main events in its history might have occurred within comparatively recent time.

Salton Sea reached an area of about 450 square miles in 1907. It has now shrunken by uneven and halting recessions to a depth of hardly more than 30 feet, or less than half the maximum, with an area of less than 300 square miles. The overflow and wastage of the vast irrigated district in the "Imperial Valley," as the southern end of the basin is designated, is such that at certain times subsidence ceases and an actual rise occurs, although each June has found the level a yard or more below that of the previous year. Conditions now prevalent, however, will soon bring the lake down to an area of about 200 square miles, where its evaporation losses and fillings will give it the character of an oscillating lake. Thus the ancient Blake Sea, followed by the ephemeral or intermittent Salton Sea, has now been succeeded by a lake the permanency of which will be coincident with our present system of agricultural practice.